Liner Overview

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Acoustics Technical Working Group Meeting

Hampton, VA

April 21 – 22, 2015

Outline

- Research Areas
    1. Liner Concepts
    2. Propagation Codes
    3. Liner Drag
    4. Liner Technology Facility Enhancements
- External Collaborations
- Research Team
- References

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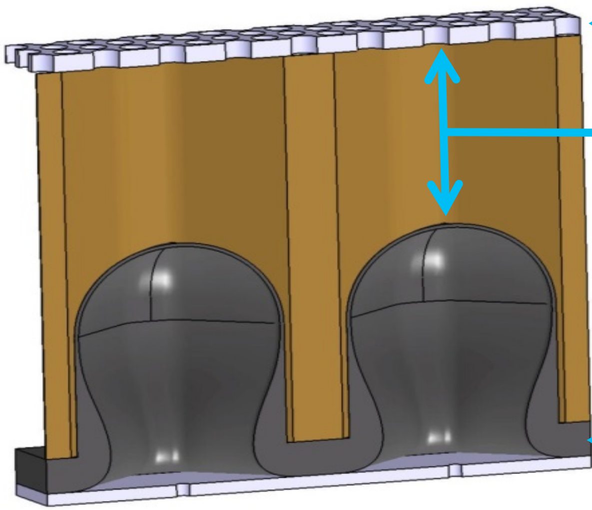
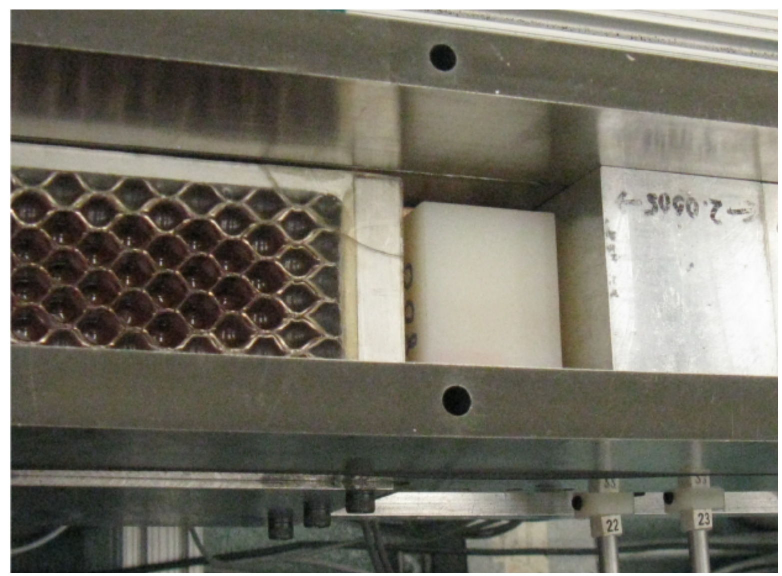
SMP-Based Adaptive Liner



Sketch provided by Cornerstone Research Group

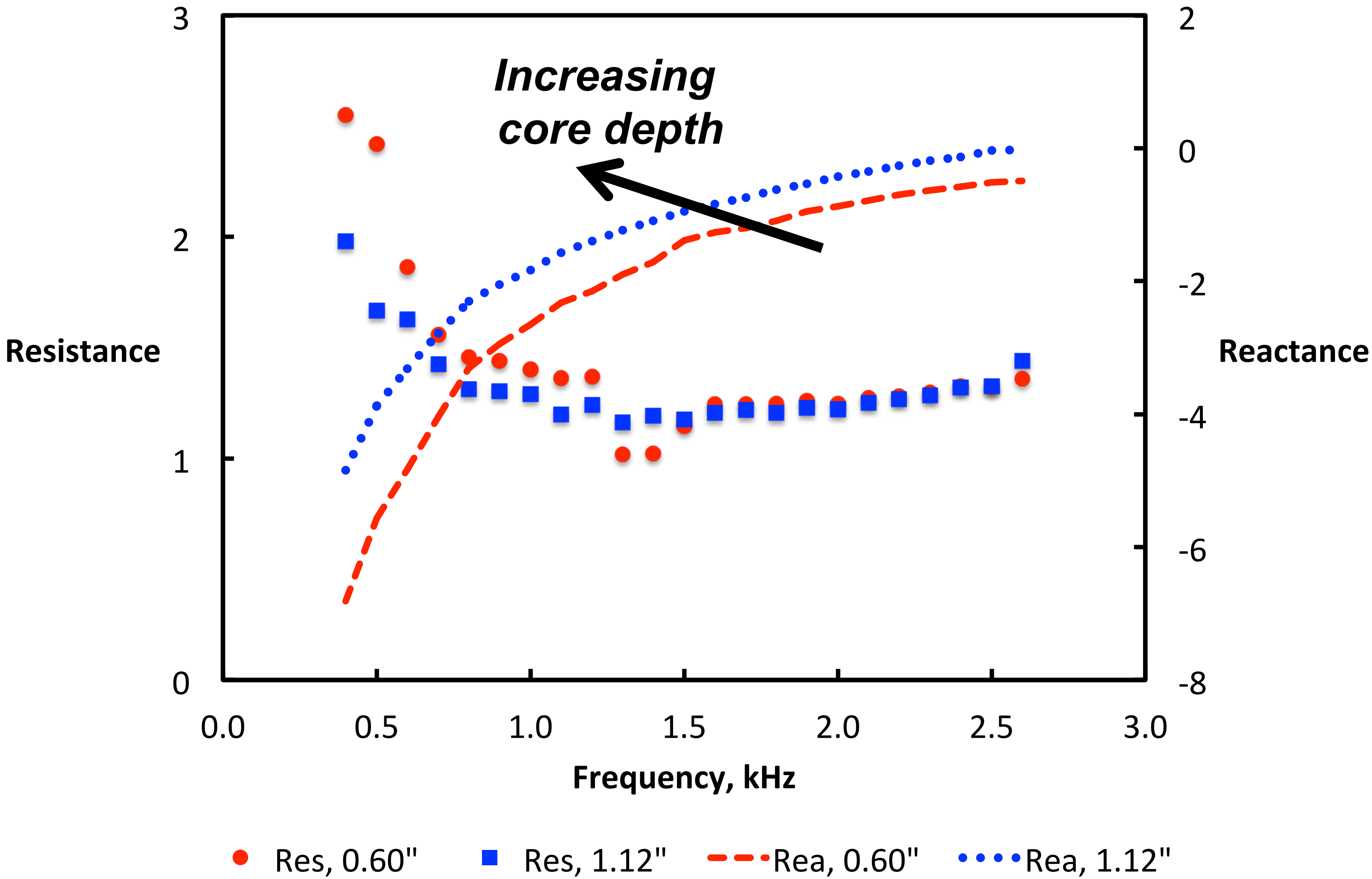


Mounted in GFIT

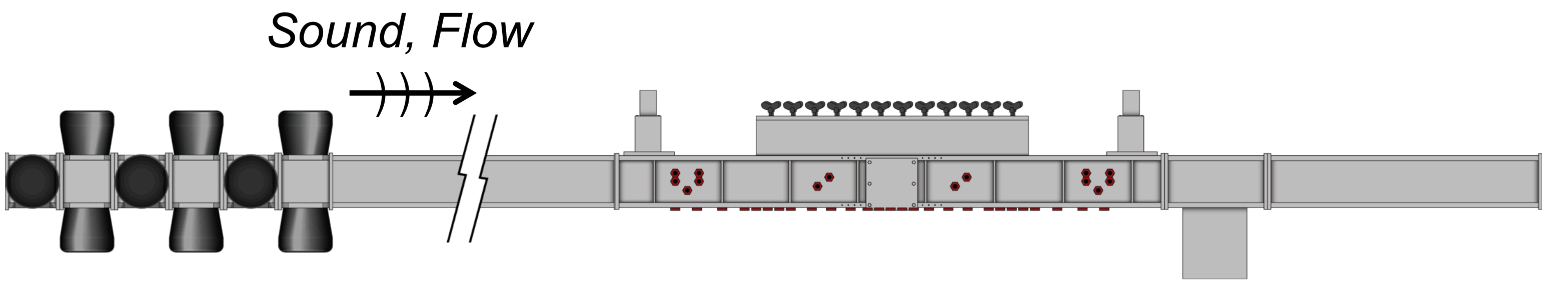
Current adaptive approach
- Add heat to SMP material
- Apply pressure to expand into honeycomb core
- Cool material to lock design
- Release pressure

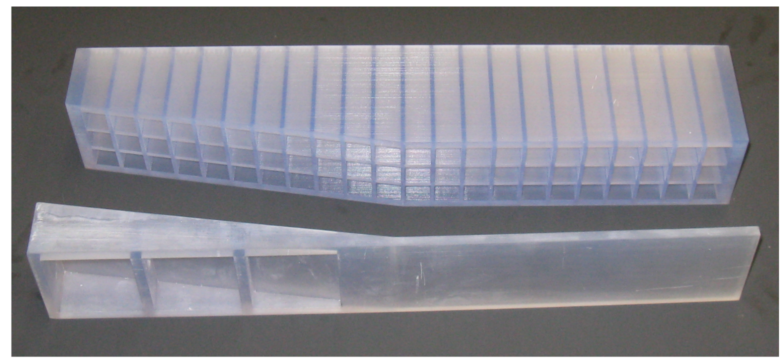
SAA with Cornerstone Research Group

Adaptive Liner – Educed Impedances

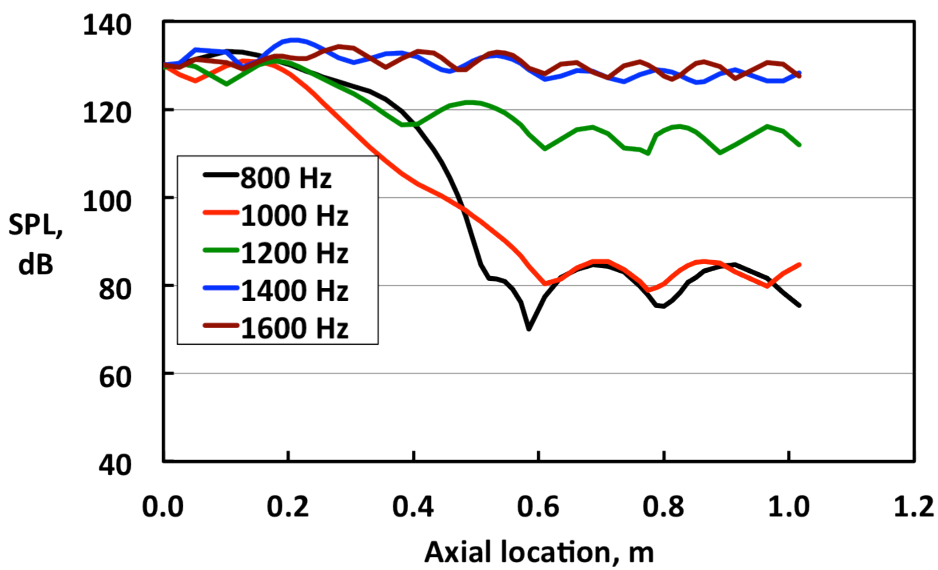


Variable Depth Liners



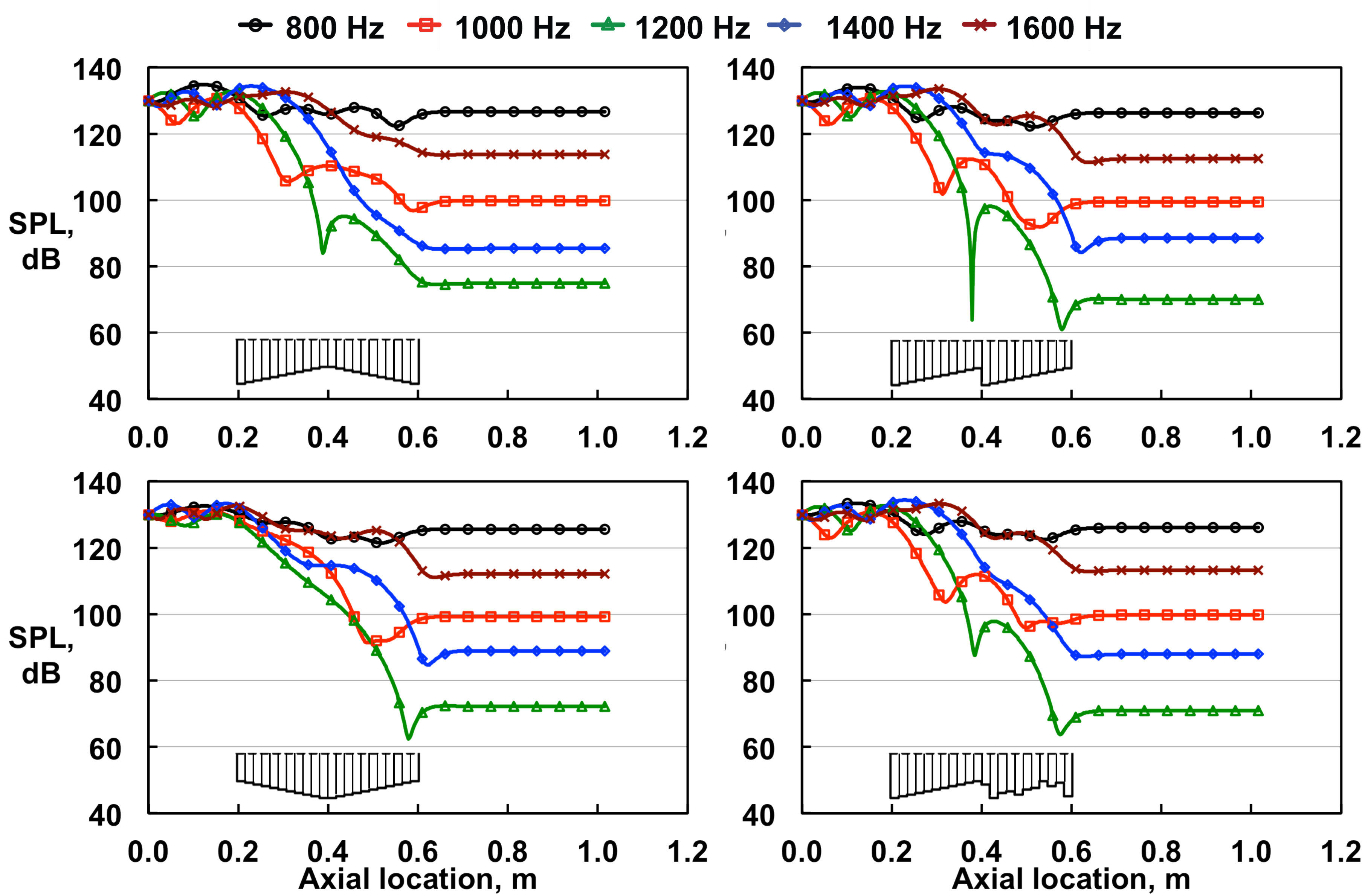


Partial variable depth liner



Variable-depth liners offer potential for significant broadband noise reduction

Variable Depth Liners – Geometric Effects



MDOF Liner Test

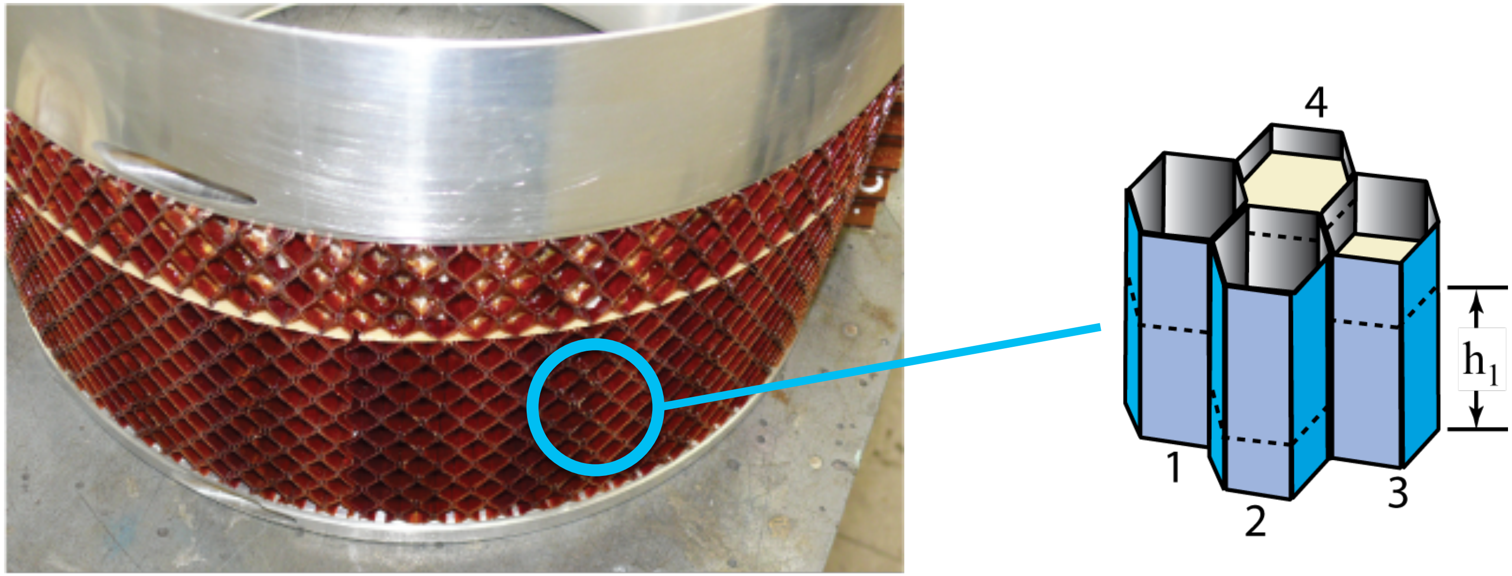


Photo of inner hub liner provided by Honeywell Corporation

Hexcel: Fabricate liner core
Honeywell: Add facesheet and back plate; provide fan rig
GRC: Conduct 9x15 test & process rotating rake and far-field data
(Miller & Sutliff presentation*)
LaRC: Design liners; Use results to validate prediction codes
(Nark presentation*)

Other Liner Development/Evaluation

- MDOF Liners
  - SAA with Hexcel
  - Seedling Fund with GRC, Honeywell (use 3D printer to investigate novel liner configurations)
- Micro-Perforate Modeling (Brown)
- Meta-Materials Concepts (Mitchell)
- Biologically-Inspired Materials (Koch)

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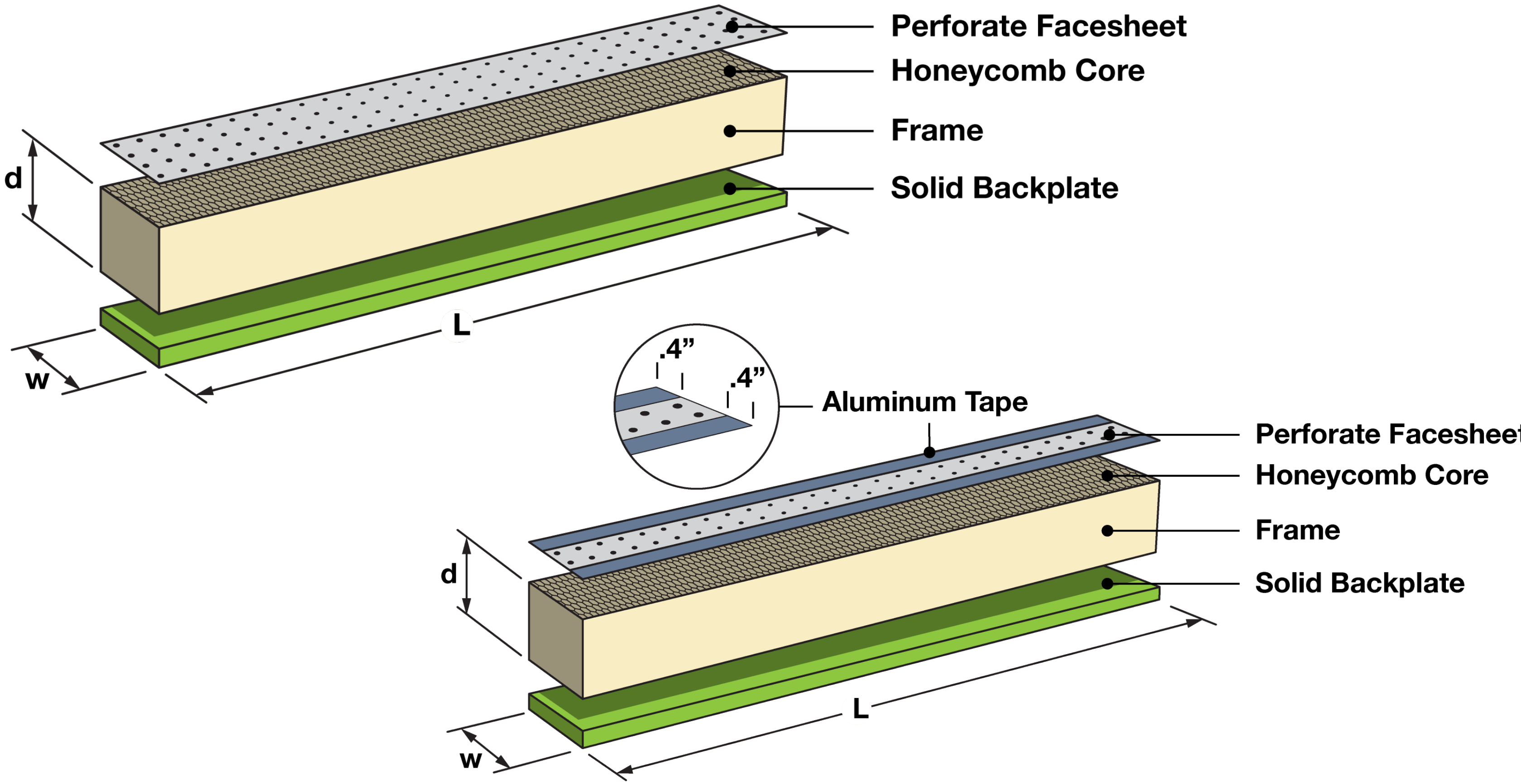
3-D Aeroacoustic Duct Propagation Code

- 2D code suitable for impedance eduction with uniform liners
- New 3D code supports impedance eduction for liners with span-wise impedance variability (Watson presentation*)



Other Propagation Code Activities

Multi-Fidelity Code

- Completed development of 3D code for constant area/uniform flow
- Developing code with speed/memory similar to CDUCT-LaRC
  - Includes variable cross-sectional area, boundary layer growth
  - Solves linearized Euler
  - Avoids need for large matrix inversion
  - Currently based upon shear-flow modes

Propagation Code Comparison

- CDUCT-LaRC, CHE, LEE, COMSOL comparison with GFIT data

Impedance Eduction

- Univ of Florida (NRA) developing matrix pencil method

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Liner Drag Activities

- Gerhold/Howerton presentation*
  - Measurement capability
  - Initial low-drag liner concepts
- Shear stress sensor development
  - Preparing to test in-house MEMS two-component shear stress sensor in a 13” wind tunnel
  - U of Florida (NRA) has built a perforate liner to support MEMS capacitive sensor evaluation in the GFID

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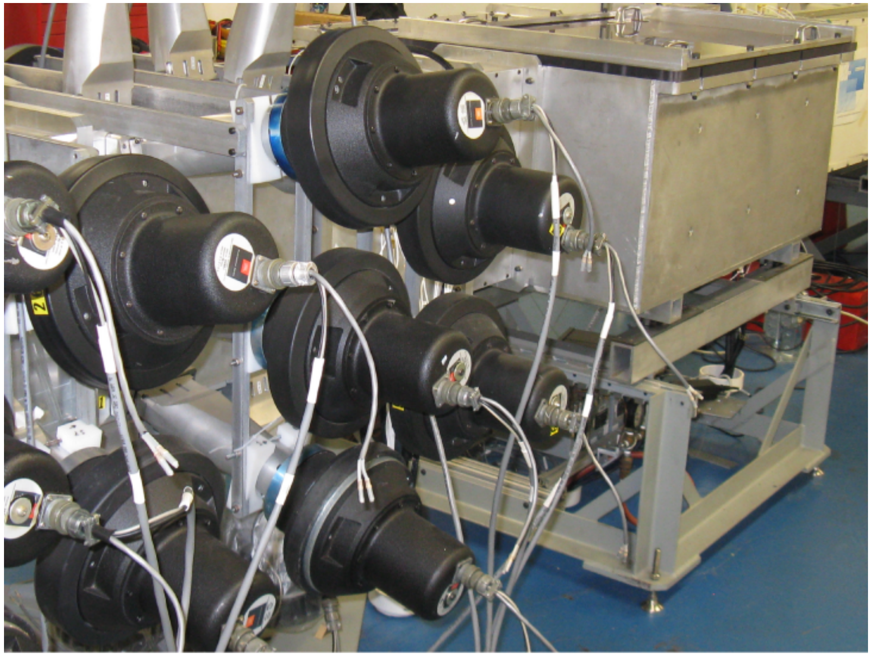
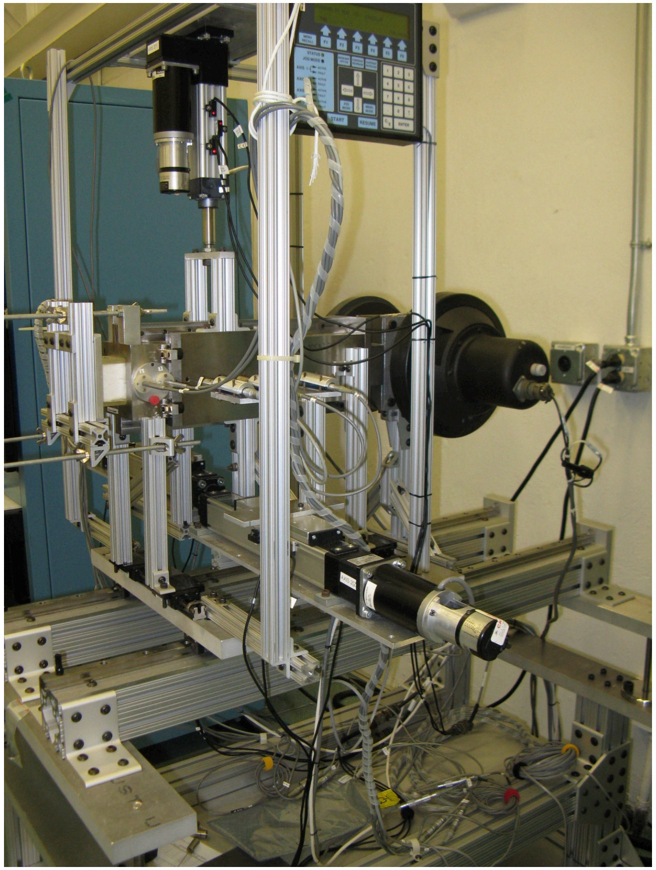
CDTR and DWNIT Enhancements



Curved Duct Test Rig:

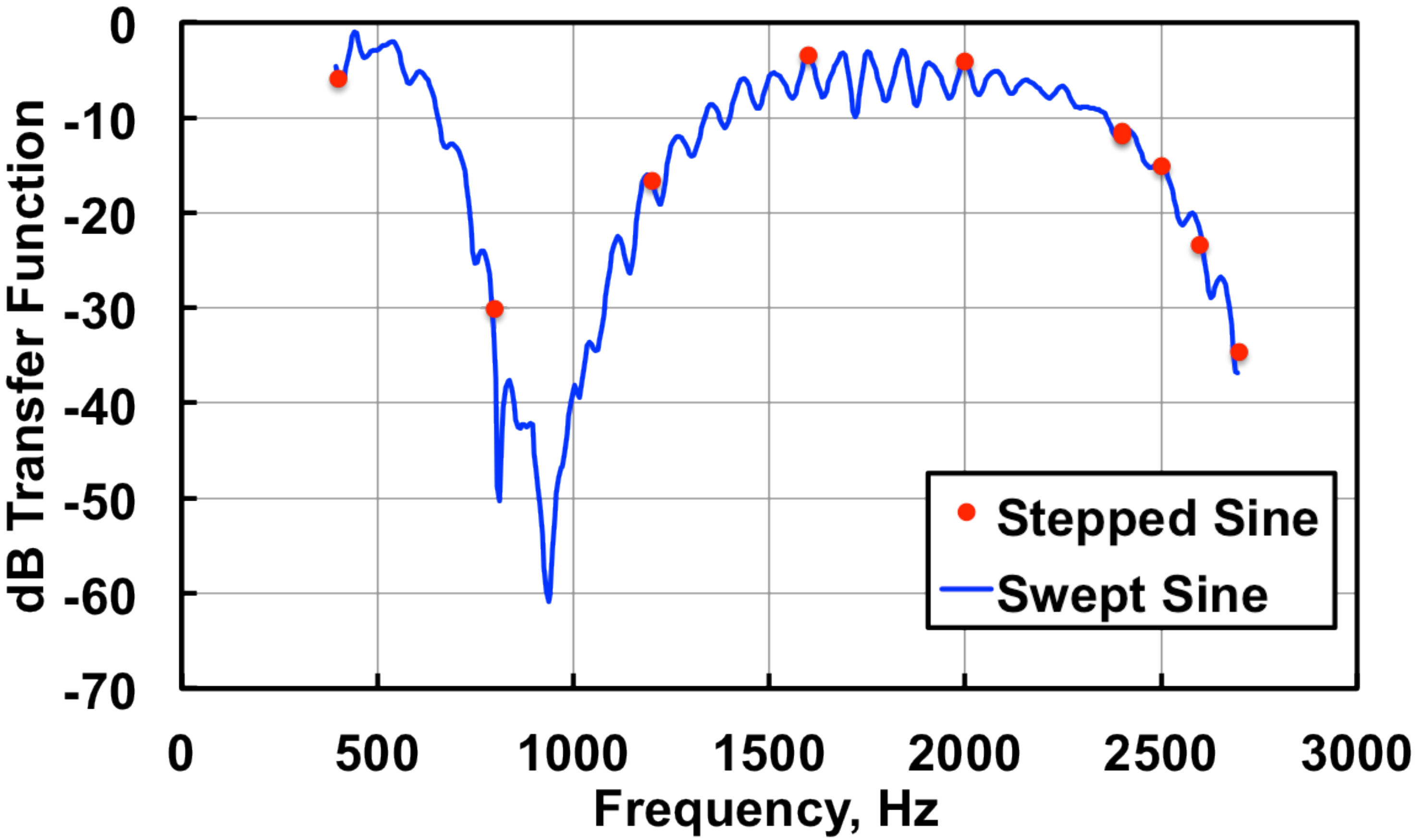
- Increased frequency range and source levels



Dual Waveguide Normal Incidence Tube:

- High-frequency liner evaluation
- High-intensity source (currently in design/fabrication)

GFIT Enhancement



Working with ATA-E to increase GFIT data acquisition rate and resolution

- Swept sine data acquisition: ~10 minutes for full frequency sweep (requires post-processing)
- Stepped sine data acquisition: 1 minute per frequency (no post-processing)

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External Collaborations

- Space Act Agreements:
  - Active: GEAE, Hexcel, Boeing
  - Completed: Cornerstone Research Group
- International Agreement: ONERA
- Seedling Fund Activities (completed)
  - Johns Hopkins University (adaptive liner back plate)
  - GRC (multi-functional low pressure turbine)
- NRA: University of Florida (shear stress sensors)
- Universities: Florida State (Tam), Notre Dame (Corke), Univ of Cincinnati (Syed), Univ of Florida (Sheplak), Virginia Tech (Fuller)

Liner Team & Contributors

M. Jones (Liner Team Lead, liner modeling, ζ eduction, liner drag)

B. Howerton (LTF data acquisition, liner modeling, liner drag)

D. Nark (propagation code development, liner optimization)

N. Schiller (COMSOL)

M. Brown (LTF manager, liner drag)

H. Haskins (designer)

M. Carpenter (propagation code development)

W. Watson (propagation code development, ζ eduction)

C. Gerhold (NIA – liner drag)

M. Scott, E. Adcock (shear stress sensor development)

C. Harrison, C. Kellam (technicians)

L. Becker, B. Leath (contractor support)

C. Jasinski, K. Mitchell (students)

References

Journal Articles

1. Jones, Watson, Howerton, Busse-Gerstengarbe: “Effects of Mean Flow Assumption and Harmonic Distortion on Impedance Eduction Methods,” *AIAA Journal,* doi: 10.2514/1.J053399 (online)
2. Watson, Carpenter, Jones: “Performance of Kumaresan and Tufts Algorithm in Liner Impedance Eduction with Flow,” *AIAA Journal*, Vol. 53(4), pp. 1091-1102

Upcoming Presentations

ASA Conference, May, 2015

1. Brown, Jones, Howerton: “Acoustic Characterization of Micro-Perforate Porous Plates”

AIAA Aeroacoustics Conference, June, 2015

1. Howerton, Jones: “Acoustic Liner Drag: A Parametric Study of Conventional Liners”
2. Jones, Watson, Nark, Howerton: “Evaluation of Variable-Depth Liner Configurations for Increased Broadband Noise Reduction”
3. Jones, Watson, June: “Optimization of Microphone Locations for Acoustic Liner Impedance Eduction”
4. Nark, Jones, Sutliff: “Modeling of Broadband Liners Applied to the Advanced Noise Control Fan”
5. Watson, Jones: “Impedance Eduction in 3D Sound Fields with Peripherally Varying Liners and Flow”
6. Mitchell, Fuller, Nark, Jones: “Design Optimization of Broadband Acoustic Liners Through Finite Element Efficacy Studies”

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